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EVALUATION OF A LOW-FIBER/HIGH-PROTEIN CANOLA PROCESSING BYPRODUCT IN HIGH COST FISH FEEDS

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Prairie Feed
RESOURCE CENTRE

Evaluation of a Low-Fiber/High-Protein Canola Processing Byproduct in High Cost Fish Feeds

A report prepared for the Saskatchewan Wheat Pool

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Objectives:

1) To determine the digestibility coefficients for dry matter, protein, energy and lipid for canola filter fines in diets fed to rainbow trout.
2) To determine the effects of feeding diets containing canola filter fines to rainbow trout on the growth, feed intake, feed efficiency and physiology.

Background:

The aquaculture feed industry is expected to triple production in the next 10 years but limited supplies of fishmeal threaten to limit this expansion. Replacement of fishmeal with plant proteins is the logical solution but has so far proven unfeasible. Soybean meal is the number one protein source for diets fed to terrestrial animals. However, when soybean meal is fed to salmonid fish at inclusion levels greater than 30% of dietary protein, fish growth performance, efficiency and immune status are negatively affected.

Canola meal has also been investigated as a protein source for fish diets. Canola meal typically contains 77% digestible protein and 8.1 MJ/Kg digestible energy when fed to rainbow trout while soybean meal contains 96% digestible protein and 13.5 MJ/Kg digestible energy (Cho, 1984) The generally poor protein and energy digestibility of canola meal is due to the presence of antinutritional factors such as fibre, carbohydrates and phenolic compounds such as tannins and sinapine, phytic acid and glucosinolates. The use of canola meal in commercial trout and salmon diets is currently limited to about 10% due to concerns regarding these antinutritional factors. Removal of the hull reduces the indigestible fibre fraction of canola meal and improves its digestibility to fish. In one study the protein digestibility of canola meal improved from 76% to 93% after removal of the hull. A low fibre canola meal might find wider acceptability for use in aquaculture diets.

Canola filter fines (CFF) is a low fibre/high oil fraction produced when the solids portion is filtered from the newly pressed oil. CFF is available in all crushing plants and this fraction has several properties that merit investigation. CFF contain approximately 36% protein (50% on an oil free basis) 30% lipid and only 4% crude fibre. The low fiber content is due to dehulling that occurs during normal processing. CFF is hexane free and does not enter the desolventiser-toster. It does not, therefore, exhibit the Maillard browning of traditional Canola meal that reduces the protein digestibility for monogastrics. CFF appear to be a canola fraction with great potential in the diets of trout and salmon. This study was done to determine the digestibility of CFF in rainbow trout and determine the ability of this product to support the growth of rainbow trout compared to other commercially available protein sources.

Materials and Method:

Digestibility Trial

Rainbow trout were maintained in 360 L tanks that were part of a recirculating system using biological filtration. Water temperature was maintained at 15°C. Dissolved oxygen, nitrated, nitrite, ammonia and pH were monitored daily. Photoperiod was a 14 h light/10 h dark cycle. The fish were fed by hand to apparent satiation twice daily for the duration of the experiment. The fish were maintained in accordance with the guidelines of the Canadian Council on Animal Care.

Apparent digestibility coefficients (ADC%) were measured by an indirect method using diets containing one percent celite as a nonabsorbable marker. The diets were formulated according to Bureau and Cho (1994). A basal diet (Table 1) was fed to a control group. The digestibilities of fish meal, soybean meal, canola meal and canola filter fines were measured by mixing the ingredients with the basal diet in a 30:70 ratio. The diets were cold extruded, dried in a forced air oven (55 °C, 1.5 h) chopped and screened to obtain the appropriate size pellet. Fish were adapted to the experimental diets for 7 days followed by a four day period when feces were collected using a settling column which separated the fecal material from the effluent water. Following collection, feces were centrifuged, frozen and freeze dried.

The ADC% for the reference and experimental diets were calculated as follows:

$$ADC = 1 - (F/D \times Di/Fi)$$

Where:

D = % nutrient in the diet
F = % nutrient in the feces
Di = % indicator in the diet
Fi = % indicator in the feces

Growth Trial

Seven dietary treatments were evaluated in this growth study: 1) Fishmeal, 2) 10% Canola Filter Fines (CFF), 3) 20% CFF, 4) 30% CFF, 5) 10% Canola meal (CM) 6) 20% Canola meal and 7) 32% Soybean meal. The diets were formulated to provide equal crude protein and lipid (Table 3). The diets were cold extruded, dried in a forced air oven (55 °C, 1.5 h) chopped and screened to obtain the appropriate size pellet.

The fish were maintained in accordance with the guidelines of the Canadian Council on Animal Care and were maintained in the same aquaculture system described in the digestibility trial. A total of Five hundred sixty rainbow trout weighing 71.2 g on average were randomly assigned to 28 tanks (20 fish per tank). The fish were fed by hand to satiation 3 times per day. Photoperiod was a 14 h light/10 h dark cycle. The experimental period was 56 days and the total tank weight of the fish was taken on days 0, 28 and 56. Feed intake was recorded daily.

Growth performance was determined by tank weight, average daily gain and feed conversion ratio (feed intake/wet weight gain). Immediately following the final weighing,

5 fish per tank were euthanized and dressout percent (dressout weight/whole wet weight x 100) was determined after removing internal organs and viscera. Liver weights were obtained for the calculation of hepatosomatic index (liver weight/body weight x 100). Analysis of the results was done using the General Linear Models procedure of SAS. Differences between treatment means were determined using the Student-Newman-Keuls test at the 0.05 level of significance.

Results

Digestibility Study

The proximate analysis of canola meal and canola filter fines are shown in Table 2. The protein content of CFF is similar to CM (34.5% vs 35.6%) but the ADF and NDF fractions of CFF are low (4.9 and 6.7 % respectively) and ether extract is high (46.9%). When CFF was fed to rainbow trout, the apparent digestibility coefficient (ADC%) of dry matter, protein and energy were significantly higher than for canola meal ($P < 0.05$) (Table 3). The protein digestibility of CFF was 0.93 and this was not significantly different than fishmeal ($P < 0.05$). However, dry matter ADC% of CFF was significantly lower than that of fishmeal ($P < 0.05$). The ADC% of protein in soybean meal was the highest of the four ingredients tested and was significantly higher than for CFF ($P < 0.05$). The ADC% of energy was 0.98 for fish meal compared to 0.82 for soybean meal and 0.79 for CFF. This suggests that the presence of indigestible or antinutritional factors in these products that reduce the availability of nutrients present in these plant protein sources.

The results of this trial demonstrate that canola filter fines are a significantly better source of protein and energy for rainbow trout than canola meal and the protein digestibility is similar to fish meal. However, the energy and dry matter digestibility of CFF is still low compared to fish meal and this limits its use in diets fed to salmon and trout.

Growth Study

There were no significant differences in feed intake between the diets during the experiment ($P > 0.05$) (Table 7). There were significant differences in mean tank weights Table 5 and average daily gains ADG (Table 6) ($P < 0.05$) and these differences all took place during the Day 28-56 period. Increasing the levels of CFF resulted in decreased mean tank weights and ADG. At 30% inclusion of CFF, significantly reduced tank weights and ADG were seen compared to fishmeal fed controls ($P < 0.05$). Surprisingly, diets containing CM did not significantly reduce tank weights or ADG. In fact, the fish fed the 20% CM diets had the best growth performance during the experiment. Soybean meal fed at 22% of the diet replaced the same amount of fishmeal as the 30% CFF diet. However, the tank weights and ADG of the Soybean fed fish were not significantly different from the fishmeal fed controls ($P > 0.05$).

Significant differences in feed efficiency were noted during both the Day 0-28 and Day 28-56 periods of the Experiment (Table 8) ($P < 0.05$). The rainbow trout fed the fishmeal diet had the best feed:gain ratios throughout the experiment with an overall

efficiency of 1.00 g feed/g gain. Increasing levels of CFF resulted in increasing feed:gain ratios. 10% CFF was not significantly different than fishmeal throughout the experiment ($P > 0.05$), however, 20% CFF and 30% CFF significantly increased feed:gain ratios ($P < 0.05$) resulting in feed efficiencies of 1.14 and 1.16 g feed/g gain respectively. Fish fed CM at an inclusion level of 20% or soybean meal had feed:gain ratios of 1.01 and 1.03 respectively and were not significantly different from the fishmeal fed controls.

There were no significant differences in dressed weight or carcass yield (Table 9) ($P > 0.05$). This was probably due to the low sample size ($N = 5$) for this measurement since there was a trend to lower dressed weights in the CFF fed fish. Liver weight and hepatosomatic index were significantly increased ($P < 0.05$) in trout fed the fishmeal diet compared to the other 6 diets. The hepatosomatic index is correlated with high levels of circulating glucose due to dietary carbohydrates. This result suggests that none of the plant protein sources has a significant effect on raising circulating glucose levels.

Conclusions:

1) Canola filter fines have better protein, energy and dry matter digestibility than canola meal.
2) Canola filter fines significantly reduced growth and feed efficiency when fed at levels greater than 10% of the diet.
3) Canola meal fed at 20% of the diet or soybean meal fed at 22% of the diet were equal to fishmeal in supporting the growth and feed efficiency of rainbow trout.
4) Although canola filter fines have reduced fibre content compared to canola meal, they still contain significant levels of other antinutritional factors. Other processing methods must be developed to produce canola protein fractions that are free of these factors. Only canola products free of these antinutritional factors will be of value to the aquaculture feed industry.

References:

Bureau, D.P. and Cho, C.Y.. 1994. Ingredient quality: An essential factor in the formulation of cost-effective aquaculture diets. In Expanding Agriculture Co-product Uses in Aquaculture Feeds Workshop Proceedings. Des Moines, Iowa, pp. 234-258.

Cho, C.Y.. 1990. Fish nutrition, feeds and feeding: With a special emphasis on salmonid aquaculture. Food Rev. Int. 6:333-357.

Table 1. Composition of the basal diet used in the digestibility study.

Ingredient	Inclusion (g/Kg)
Fishmeal	300
Soybean Meal	170
Corn Gluten Meal	130
Wheat Flour	280
Vitamin/Mineral Premix	10
Celite	10
Fish Oil	100
Total	1000

Table 2. Proximate analysis of canola meal and canola filter fines used in the experiment. Values are based on the means of 12 samples and are expressed as percent on an as is basis.

	Canola Meal		Canola Filter Fines	
	Mean	s.d.	Mean	s.d.
Moisture	11.7	0.57	3.4	0.67
Crude Protein	35.6	0.73	34.5	1.24
Acid Detergent Fibre	17.0	0.77	4.9	1.70
Neutral Detergent Fibre	24.2	0.75	6.7	2.39
Ether Extract	<1.0	n.a.	46.9	4.24

Table 3. Apparent digestibility coefficients of fishmeal, soybean meal, and canola products when fed to rainbow trout.

	Dry Matter	**Crude Protein**	**Lipid**	**Gross Energy**
Reference Diet	0.72	0.94	0.96	0.81
Ingredient Digestibility				
Fish Meal	$.95^{a}$	$.96^{ab}$	1.10	$.98^{a}$
Soybean Meal	$.78^{b}$	$.99^{a}$	1.30	$.82^{b}$
Canola Filter Fines	$.72^{b}$	$.93^{b}$	0.97	$.79^{b}$
Canola Meal	$.51^{c}$	$.88^{c}$	1.28	$.54^{d}$

^{abcd} Columns with the different superscripts are significantly different ($P < 0.05$).

Table 4. The diet formulations used for the rainbow trout growth study.

	Diets						
Ingredient	Fishmeal	CFF 10%	CFF 20%	CFF 30%	CM 10%	CM 20%	SBM 32%
Fish meal	600	550	500	450	550	500	450
Canola Filter Fines	0	100	200	300	0	0	0
Canola Meal	0	0	0	0	100	200	0
Soybean Meal	0	0	0	0	0	0	219
Wheat	260	230	199	168	196	132	160
Wheat Gluten	1	6	11	17	12	23	18
Fish Oil	116	91	67	42	119	122	130
Ascorbic Acid	1	1	1	1	1	1	1
Choline Chloride (70%)	6	6	6	6	6	6	6
Trace Mineral Premix	1	1	1	1	1	1	1
Vitamin Premix	15	15	15	15	15	15	15
Total	1000	1000	1000	1000	1000	1000	1000
Total Protein	453	453	453	453	453	453	453
Total Lipid	180	180	180	180	180	180	180
Total Fishmeal protein	420	385	350	315	385	350	315
Total CM protein	0	0	0	0	35	70	0
Total CFF protein	0	35	70	105	0	0	0
Total Soy protein	0	0	0	0	0	0	105
Total Wheat protein	29	30	30	30	30	31	30

Table 5. Total mean tank weights of fish during the experiment.

Diet	N*	Day of Experiment 0	28	56
Fish meal	20	1426.0	2621.4	4071.1[b]
CFF 10%	20	1420.6	2522.6	3773.4[ab]
CFF 20%	20	1429.4	2535.8	3750.2[ab]
CFF 30%	20	1431.3	2483.9	3652.0[a]
CM 10%	20	1422.0	2495.0	3743.8[ab]
CM 20%	20	1418.9	2603.5	4088.9[b]
SBM 22%	20	1419.6	2622.7	3867.4[ab]

[ab] Columns with the different superscripts are significantly different ($P < 0.05$).
*The number of fish per tank. No fish died during the experiment.

Table 6. Average daily gains (g/d) of fish during the experiment.

	Experimental Period Day 0-28	Day 28-56	Day 0-56
Fish meal	2.13	2.59[b]	2.36[b]
CFF 10%	1.97	2.23[ab]	2.10[ab]
CFF 20%	1.98	2.17[ab]	2.07[ab]
CFF 30%	1.88	2.09[a]	1.98[a]
CM 10%	1.92	2.23[ab]	2.07[ab]
CM 20%	2.12	2.65[b]	2.38[b]
SBM 22%	2.15	2.22[ab]	2.19[ab]

[ab] Columns with the different superscripts are significantly different ($P < 0.05$).

Table 7. Average daily feed intake during the experimental period.

	Experimental Period Day 0-28	Day 28-56	Day 0-56
Fish meal	1397.5	2673.8	4071.1
CFF 10%	1491.6	2749.6	4037.5
CFF 20%	1529.4	3043.0	4275.2
CFF 30%	1617.4	2955.9	4236.3
CM 10%	1549.9	2819.3	4155.6
CM 20%	1475.7	2577.4	4129.8
SBM 22%	1433.8	2727.6	3983.4

Table 8. Feed conversion ratio (g feed/g gain) during the experimental period

	Experimental Period		
	Day 0-28	Day 28-56	Day 0-56
Fish meal	0.98^{a}	1.02^{ab}	1.00^{a}
CFF 10%	1.05^{ab}	1.09^{abc}	1.07^{ab}
CFF 20%	1.07^{bc}	1.2^{c}	1.14^{bc}
CFF 30%	1.13^{c}	1.19^{c}	1.16^{c}
CM 10%	1.09^{bc}	1.13^{bc}	1.11^{bc}
CM 20%	1.04^{ab}	0.99^{a}	1.01^{a}
SBM 22%	1.01^{ab}	1.04^{ab}	1.03^{a}

^{abc} Columns with the different superscripts are significantly different ($P < 0.05$).

Table 9. Carcass yield, liver weights and hepatosomatic index (HSI) of fish at the end of the experiment.

	Wet Weight	Dressed Wt	Yield	Liver Wt	HSI
Fish meal	200.10	170.92	85.4	3.00^{b}	1.49^{b}
CFF 10%	193.30	163.17	84.4	2.26^{a}	1.17^{a}
CFF 20%	194.10	166.84	86.0	2.52^{a}	1.31^{a}
CFF 30%	194.80	163.23	83.8	2.23^{a}	1.15^{a}
CM 10%	189.30	160.64	84.9	2.32^{a}	1.23^{a}
CM 20%	206.60	177.81	86.1	2.41^{a}	1.18^{a}
SBM 22%	208.90	175.99	84.2	2.37^{a}	1.14^{a}

^{ab} Columns with the different superscripts are significantly different ($P < 0.05$).

Summary for project 19980277

The project determined digestibility coefficients for canola filter fines and its feeding potential in rainbow trout. Results indicated that canola filter fines have better protein, energy, and dry matter digestibility than canola meal. Filter fines significantly reduced growth and feed efficiency when fed at levels greater than 10% of diet. Canola meal fed at 20% of the diet produced a similar effect as soybean meal fed at 22%.

Canola filter fines have other antinutritional factors that must be removed by further processing to enable full utilization as aquaculture feed.